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ABSTRACT

As part of Unesco's program in science and technology, a pilot project on "Technology in General Education" was cooperatively initiated by Australia, China, India, and the Philippines. The major objective of this project was to develop methods and materials for technology teaching as part of the general education and was expected to cover the secondary school level including out-of-school activities related to technology. This document reviews the results of a consultation meeting on the progress of this pilot project. The procedures and experiences of the project are reviewed for each of the four participating countries. Perspectives are also offered on: (1) guidelines for identification of basic content; (2) resources and constraints; (3) approaches to technological education; (4) education in, about, and through technology; (5) organization of the curriculum; (6) teaching methods; (7) teacher preparation and in-service courses; and (8) assessment and evaluation procedures. (ML)

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UNITED NATIONS EDUCATIONAL
SCIENTIFIC AND CULTURAL ORGANIZATION

CONSULTATION MEETING ON PILOT PROJECT

"TECHNOLOGY IN GENERAL EDUCATION"

Beijing, 3-5 April 1984

FINAL REPORT

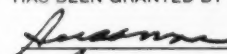
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INTRODUCTION

As part of Unesco's programme in science and technology for 1981-83 (objective 4.4 of 21 C/5) a pilot project on 'Technology in General Education' was initiated with the participation of Australia, China, India and the Philippines.

The major objective of this project was to develop methods and materials for technology teaching as part of the general education. Based on the analysis of the existing curricula, particularly in science education, it was intended to give selected topics a practical and technological bias for better understanding of the surrounding environment.

The scope of the project was expected to cover mainly the secondary school level, including out-of-school activities related to technology (both modern and traditional) in the fields of agriculture, industry, etc.

The present meeting of representatives from national institutes of participating countries - Australia, China, India and the Philippines was organized by the Chinese National Commission for Unesco under contract with Unesco and was convened by the Beijing Municipal Bureau of Education at the Audio-Visual Centre, Beijing, 3-5 April 1984.

The meeting started with welcome speeches by Mr. Yang Yumin, Deputy Director, Beijing Municipal Bureau of Education and Mr. Jia Xueqian, Deputy Secretary-General of the Chinese National Commission for Unesco. While stressing the significance of science and technology in the process of national development and reconstruction, they praised the Director-General of Unesco for his willing co-operation with China to hold this important meeting in Beijing. Mr. Yang remarked that rapid developments in science and technology are causing rapid socio-economic changes. Science and technology education, while training much needed manpower for national reconstruction and development must also help to equip our students to meet the challenges of social and technological changes.

Mr. Jia praised the programme activities of Unesco for the improvement of science and technology education. He said that China is a developing country where education is regarded as the foundation and science and technology as the key for progress and well-being of its people. As such, the pilot project, which aimed at developing the use of both the hand and the head, was most welcome.

TECHNOLOGY AND ITS EDUCATION

Technology is as ancient as the primitive man who first learned to use stone or wood for food and protection. With the passage of time, various other methods and techniques were developed, possibly by 'hit-and-trial', either to satisfy certain basic human needs or to solve certain problems in response to changing environment. Thus stone and wood implements of different kinds, making of pottery, drawing of water from the well using a pole with a

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stone tied to one of its ends, covering of clay houses with cow-dung paint for protection against rain, etc. can be quoted. But in the present age of sophisticated technology, it is easy to forget this long association of technology with our civilization. Knowledge of technology develops cumulatively through use and modification and is passed from generation to generation as cultural heritage. The first industrial revolution (1760-1860) was, in fact, based on craft-technology having little to do with the science of that period.

With the advent of science education in schools, the teaching of craft-technology has either been eliminated completely or reduced to an optional hobby subject with no bearing on the final examination. With greater emphasis on university education, the school curricula were increasingly modified for entry into the tertiary education. Thus, the school has slowly become a world different to the one from which students come to learn. It is an artificial world of chemistry, physics, biology or mathematics, etc., remote from the problems of life and living.

In recent years science and technology have made tremendous strides and have become integral parts and the driving forces in our culture and everyday life, everywhere. They affect all aspects of our life and cause them to change. As a direct consequence of this change, situations are created with ever-increasing demands on the problem-solving and decision-making responsibilities of man to cope with such changes. Thus, there is a host of skills, techniques and processes associated with technology which an individual must learn in order to survive effectively in his environment. Under the circumstances, the school should be a place where teachers and students can interact in order to prepare future citizens for a life of work in a society. This may or may not require tertiary studies.

In order to achieve the above-mentioned objective, technology in the form of technical and vocational education was introduced into general education. In some places, special schools (e.g. trade schools) were created; while at others, new streams parallel to the academic ones were introduced for the purpose. Unfortunately, this was mainly done to catch the ever-increasing numbers of students dropping out of the rigid and heavily academic school system, there being little or no attempt in evolving curricula which could blend technology with the sciences to make education more compatible with the changing needs of society, as well as for the life of its individual members. The immediate consequence of the afore-mentioned dichotomy has been that almost all of the students in the academic schools remain ignorant of the rudiments of technology. If education is regarded as a means for promoting economic growth, technology education must have a place at all levels and streams of the education system. While we need engineers and technicians for industrial growth and development, we also need a population who is knowledgeable and supportive of science and technology in daily life. The introduction of technology as component of general education, in particular, linked to science in the school curriculum, among other things, should aim at developing such a population. This will, hopefully, facilitate the transfer and adoption of technology, and thus encourage the development process in the country.

Science education has a long history and over the years; it has become an integral part of general education in most countries. In many cases, however, its teaching has been rather prestigious and purely academic. Thus, lacking in emphasis on its practical applications in daily life, its learning and teaching in schools has lost much of its effectiveness and utility as an

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educational tool for development.

On the non-formal basis, technology education even precedes science education; but within the context of the formal school education system it has, unlike science education, acquired a general disdain. This is not to deny the fact that there have been attempts to encourage technology education as part of general education. However, efforts to develop curriculum activities to teach through technology have mostly remained isolated in schools or countries where they were started. Some of these initially gathered popularity but soon withered away because they were seen as too great a challenge to the existing resources and predominant patterns of pedagogy and classroom organization.

Today, in view of the ever-increasing interaction of technology with our daily life, the question of its contribution to general education cannot be ignored. In considering this, however, the major concern should be not so much for education of the future technologists but education of the majority living as non-technologists in a technologically-based society. This implies an understanding of the functioning of the ever-increasing products of technology as well as the design and problem-solving processes of technology. As part of general education, technology education need not focus exclusively on high technology like computers, nuclear reactors and invitro-fertilization methods and/or various complicated manufacturing processes contributing to courses for specialized technicians or engineers. Thus, within the framework of the pilot project, the group regarded technology as an application of knowledge for making and doing purposeful or useful things, as well as an aid to understanding our technological environment. It aims at developing our ability to employ our resources for human benefit. Technology education may be considered a means to find new and better ways of solving problems and satisfying our needs and comforts.

The group also felt that technology education in general school curriculum (inter-linked with natural and/or social sciences) should not ignore the study of local and traditional technologies (techniques and processes etc.) which contribute to the technological environment to which the child is first exposed. Here it is necessary for the teacher to stress and explain that these endogenous techniques have not always been in existence in situ. They change from time to time in the light of new knowledge and discoveries. The present-day technologies have roots in the past and will surely continue into the future. Technology education should also emphasize and provide practical work to be carried out in school or in the field to encourage inventiveness and problem-solving. Thus some of the teaching-learning activities could consist in taking things apart, putting them together, studying how they work. They could also relate to routine maintenance, repair or production of simple technological designs or objects in association with applied aspects of science. This may help to reconcile manual work and intellectual activity.

OBJECTIVES

In introducing technology education as component of general education, the Meeting considered many objectives which are summarized as below:

- to make general education more relevant and realistic to the environment and daily life of students
- to prepare the student for life in a society increasingly based on science and technology and their products
- to equip students to be useful members of the community with an

attitude to contribute their best to the common good in school, home and community life

- to motivate the students to explore, experiment and express individual creativeness
- to impart an understanding of the design and problem-solving processes characteristic of technology
- to encourage critical thinking with clean and safe work habits i.e. to train students in the constructive use of both the head and the hands
- to develop positive attitudes of economy, team-work, ethics and socially desirable values such as self-reliance, dignity of labour, tolerance, co-operation, sympathy and helpfulness
- to impart to students a basic knowledge of materials, processes and techniques with a view to their introduction to the world of work
- to encourage students develop practical skills and techniques e.g. graphic communication, use of elementary hand-tools and equipment, scientific method and problem-solving techniques
- to develop in students an appreciation of the role of agriculture and industry in the development of the country
- to impart to students knowledge and related skills necessary for the development, conservation and wise utilization of natural resources; discouraging waste and pollution.

PROCEDURES AND EXPERIENCES

AUSTRALIA

Two institutions in the State of Victoria, the Hawthorn Institute of Education and the State Department of Education undertook joint responsibility for conducting the Unesco pilot project on technology in general education.

The advisory committee for this project was not formally established until late in 1983. However, despite its late start, the Committee planned to complete all its commitments to the project by June 1984.

In reviewing the state-of-art on the subject of the pilot project, the Committee noted that within the framework of high school science, technology was considered worthy of only passing comments and often disdained. Technical schools and craft subjects were frequently seen as safety nets for students who are not academically gifted. "Trade subjects" like metalwork, woodwork and electronic practices were often regarded as vocational training in technical skills rather than contributors to general education. In short, the Committee found that Australian schools had not granted to technology the place in culture readily conceded to literature, art, science and mathematics. This

was not denying the fact that there was inclusion of aspects of technology in subjects like science, home economics, graphic design and woodwork. But there were attitudes towards technology and technology education which were considered not very conducive to the spirit of the pilot project.

Accordingly, for the purpose of the pilot project, the Committee regarded technology as the conscious adaptation of materials and processes to accomplish human purposes. In seeking to promote technology as component of general education, the Committee sought to emphasize, above all, those processes of problem-solving and decision-making through which young people might have first-hand experience in applying technological processes to the solution of worthwhile problems. Further, these people ought to be invited to design, build and test technological solutions to selected problems.

In view of the limited budget, the project was viewed as a "seeding" exercise within the state of Victoria, and its scope was limited to the secondary schools; restricting the age range of students involved, rather than reducing the subject areas to be incorporated. This selection was somewhat arbitrary, though secondary school teachers are more likely to have backgrounds and resources in a wider range of technologies than those of primary school teachers, hence allowing a greater selection of activities for experimentation.

General goals of the project included clarification of objectives, rationale for introducing technology education in schools, identification of teachers who were already experimenting with technology education, development of support systems and publication of examples of technology education that had been developed, tried, tested and shown to be effective in Victorian schools.

In selecting and/or producing teaching-learning materials, short, independent activities were preferred to structured sequences or whole courses with emphasis on "education through technology". This strategy permitted fewer assumptions about the "right" kind of activity and the product proved to be more clearly exploratory and open to experimentation by the teachers who are oftentimes dissuaded by the magnitude of the project. Consistent with the preference for short activities, the project placed high priority on exercises which aimed at providing students with opportunities to design, build and test technological solutions to particular problems.

The overall concern of the project was the general education for all students and not vocational training or preparation of future engineers. Although some students might make direct use of technology education in choosing and deciding their future vocations or careers, the needs of such students were not regarded crucial in developing the approach and content of technology education curriculum in the context of general education.

Instead of starting from scratch and following the widely used "research-develop-disseminate" pattern of curriculum design, the Committee chose to seek from practising teachers materials which they had developed and tested in the field of technology education. The learning experiences envisaged by the Committee were to emphasize active involvement of the students in technological design and problem solving. Young people should see the problem as being of real value to them and to their community, rather than just an exercise

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to educate them. Solution of a central problem required solution of a range of practical problems along the way. Students needed to search for information and select materials of possible relevance to the problems. They also needed to evaluate the efficacy of their solutions, and modify them where necessary. They needed as well to consider how these particular solutions could be made more general: whether they could be incorporated into a larger context of problem solving; what would happen if the constraints and parameters of the original problem were changed significantly. Curriculum materials needed to address questions of methodology insofar as these relate to opportunities for young people to work collaboratively, to plan projects, to allocate time, to discuss tentative solutions and to interact with their teacher.

The Committee also resolved that various curriculum materials so selected should be presented in a style similar to that of "case-studies"; stressing their exemplary contribution under the pilot project was to be described by its author/authors under such headings as: title, context and background, reasons for submission, objectives, methods and activities, student assessment, role of the teacher and evaluation of exercise.

The Committee adopted the following criteria in selecting various contributions related to curriculum materials and teaching methods, etc. in pursuing the pilot project:

APPROPRIATE OBJECTIVES such as

- increasing students' capability for solving practical problems through technological means (e.g. materials, tools, energy sources, etc.)
- developing positive attitudes towards making and doing rather than knowing and following directions
- encouraging inclination to work from problem to solution
- showing concern for application of knowledge and not merely its acquisition
- promoting better understanding of technological environment.

APPROPRIATE MEANS with emphasis on

- context analysis, design, realization, trial
- a problem solving approach
- systematic "theory" (e.g. analysis of problems in terms of needs and the characteristics of potential solutions; and of products/materials/processes in terms of their appropriateness to the solution)
- student activity
- appeal and challenge to wider range of students.

TEACHING-LEARNING UNITS

The following curriculum units were suggested and developed to yield the teaching/learning materials and assessment items under the pilot project:

- a) design and construction

- b) textiles' education
- c) environmental studies
- d) rural studies
- e) home economics.

PEOPLE'S REPUBLIC OF CHINA

In China, the pilot project was located at the No. 4 High School, one of the leading institutions of learning in Beijing. The educational policy of the country stipulates a three-pronged approach to develop students morally, intellectually and physically and thus help them to become useful members of their community. For the pilot project, two elective courses, one each on 'astronomy' and 'biology medicine' were designed for students who started their senior schooling in September 1982. These subjects were chosen for their usefulness and applicability in everyday life as well as for their integrated approach to science and technology. Weather monitoring and agricultural patterns relate to astronomy and hence its significance in life. Biology is one of the rapidly developing modern sciences, affecting all aspects of our life. A course in biological medicine can play a significant role in developing good hygienic habits and for improving the general level of health of the people in the country.

The broad contents of the courses on biological medicine and astronomy are as follows:

- biological medicine

- . human anatomy and physiology with emphasis on cardio-vascular (circulatory) and nervous systems
- . medical microbiology including the bases of immunity
- . the Chinese herbal medicine.

- astronomy

- . introduction to astronomy
- . fundamental knowledge of celestial bodies such as the solar system, stars and galaxies, etc.
- . fundamental knowledge of spherical astronomy and practical astronomy with emphasis on celestial co-ordinate system, time, calendars and navigational astronomy
- . contemporary astronomy: radio astronomy, exploration of space, etc.

The instructional activities of the project have been carried out in the following four stages:

1. Planning

This was completed in a six-month period (March to September 1982). During this phase instructional materials for the course were developed by the teachers.

2. Instruction

The two courses were taught in the fall semester of 1982 and the spring semester of 1983.

3. Summer camp

It was held for imparting practical information and skills related to the courses to be held from 3-12 August, 1984.

4. Research and evaluation.

This phase commenced in September 1983 and was continued upto the end of April 1984.

The instructional activities consisted of systematic teaching of the two courses by the participating teachers for one academic year together with lectures on special topics by experts.

The integrated approach to science and technology can be illustrated by the following two examples:

Children are always urged by their parents and grand-parents to wash their hands before meals. To understand the scientific background behind this social custom the students were asked to touch with clean and dirty hands two culture media which were then incubated. At the conclusion of the experiment, the class could observe the rapid development of bacteria in the culture medium touched by the unclean hands.

In another experiment, students were made to study the relationship between white and red blood corpuscles. The abnormal count of these cells reflect the malfunctioning of the body.

The course on biological medicine emphasized the contributions of the Chinese herbal medicines through the ages. The course on astronomy helped students to understand nature correctly.

INDIA

In India the pilot project was conducted at the Regional College of Education, Mysore, using its physical facilities, human resources and its contact with the national school system of India. The college is a constituent unit of the National Council of Educational Research and Training which is primarily responsible for providing academic support in improving the quality of school education in India.

The project design was based on the following hypotheses:

1. The present secondary school curriculum does not provide students with opportunities to know, understand and use materials and processes of production, construction and operation.
2. Thus students in the secondary schools do not experience systematic design processes and/or come across situations to understand and practise designed procedures and evaluation of the designed solutions in terms of human needs.

3. Inclusion of technological activities in the school science curriculum, as a part of general education, will motivate the school leavers to accept and use the technology for their individual/family/community purposes.

The definition of technology as a process of problem-solving and decision-making for meeting the responsibilities and purposes of daily life was accepted as the working definition for the project. Introduction of technology as a discipline distinct from the curriculum of vocational and technical education was not feasible because of constraints from school curriculum and resources. An attempt was made to prepare instructional material on some topics of the existing science curricula of the secondary school with a view to introducing technological elements such as design, resources, laws of nature and the human purpose. Thus seven topics of energy, friction, combustion for light, household electricity, electro-magnetic devices, wheat to biscuit and design-your-diet were selected for preparing instructional modules. Each module contains:

- a) self-instructional materials and worksheets for students
- b) teacher's guide and c) equipment kit.

The module on combustion was prepared to highlight technological design changes in everyday household appliances such as the hurricane lantern and wick-stove which work on the same fuel (say, kerosene) using the principle of combustion. The module on household electricity was designed to develop in children competency for solving wiring problems related to household electricity and electrical appliances. The children should learn why different types of wires, cables, switches and plugs are commercially produced. The module on simple machines and energy was prepared to stress the design aspect of everyday appliances. This involves the principle of simple mechanical machines such as lever, pulley and screw, as well as the principle of conservation of energy. The other modules were intended for a thrust, wherever possible, to technological treatment of concepts. For each of the modules, a kit for doing appropriate experiments together with detailed worksheets were developed. These modules were translated into Kannada before trial in selected schools in Mysore and its vicinity. The reaction has been a favourable one though detailed report at the time of this publication was not available.

The pilot project has served many purposes though research on the effectiveness of the modules in a classroom situation is yet to be completed. It has encouraged the project team to find ways and means to bring the teaching of science closer to the life and environment of the learners. So far, in teaching science, the emphasis has remained confined to the development of observational skills, looking for patterns in the observations, making generalizations and constructing models to wonder "why". Problem-solving and understanding of technological design processes are the important dimensions that have emerged out of the initial work in this project. This has created the necessary foundation for further work in this field.

Teachers are the pivot of all experimentation in education and unless their own minds are oriented properly to the theme the question of their being able to influence the students will be remote. A series of in-service programmes for training teachers in order to spread the project theme to a wider spectrum of rural and urban schools has been planned. It is hoped that the expertise developed and the instructional materials produced under the pilot project will prove useful in improving the quality of general education.

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THE PHILIPPINES

In the Philippines, the pilot project was conducted by the Technology Resource Centre (TRC), a corporate agency of the Ministry of Human Settlements. The work was carried out in five phases:

Phase 1

This comprised a survey to determine the level of technology awareness as well as the needs of the Filipino (January 1982).

Phase 2

Under this phase, a national workshop with the participation of teachers, professors, science educators, administrators, agronomists, technologists and text-book writers was organized (May 1982). It suggested that:

- technology education be needs-oriented
- science and technology information include the "how-to-do or demonstrate" aspect
- linkages with the media be strengthened and maintained
- a "data bank" for science and technology research be established
- macro and micro systems of monitoring and evaluating the use of instructional materials to be produced under the project be developed
- science and technology teachers and those involved in technology information dissemination be intensively trained.

Phase 3

Following the suggestions arising in phase 2 a "technology enriched" curriculum embodying the principles of science and technological skills with emphasis on their applications in everyday life was designed to meet the national goals emerging from the eleven basic concerns (food, water, shelter, clothing, livelihood, health, education (including culture), ecological balance, sports (including recreation), mobility and power i.e. economic base) of the Ministry of Human Settlements.

A teachers' guide and a students' manual on instruction materials comprising appropriate technologies were also prepared. These were supplemented with a set of 'do-it-yourself' technology-cum-livelihood brochures and ecology posters as well as audio-visual materials.

Phase 4

This involved two teacher-training seminars. In the first, the participants (curriculum experts, science teachers, and professors, principals of schools, etc.) examined the appropriateness of instructional materials developed under phase 3 and deliberated on ways of interlinking technology and science in general education and developed approaches for the effective use of the said materials. Specifically, the seminar:

- arranged according to priority the appropriate technologies that can be injected into secondary science courses
- identified available resources in the communities which can be used as teaching aids or support materials in the teaching of interlinked science and technology
- devised methods for teaching interlinked science and technology by preparing lesson plans on science and technology application for teacher's use
- determined science and technology topics which can be filmed for classroom use or prepared in similar audiovisual teaching aids
- accomplished qualitative improvement of the learning-teaching materials developed under the project.

The second seminar was held for the pilot teachers who were selected to pilot test the curriculum and other supplementary teaching-learning materials.

Phase 5

This phase was concerned with the pilot testing and other activities to enhance the learning process. The latter included films and demonstrations to show the practical applications of scientific concepts, dramatization of scientific principles, technology exhibitions and contests to foster the spirit of co-operation and initiative among students, and visits to research and development laboratories as well as industries in the vicinity.

The pilot class teachers became members of the Science and Technology Association, a group organized in the early stages of the project with a view to upgrade the teaching of science and technology in schools.

Conclusions

Based on the implementation of the pilot project on "interlinked science and technology in general education", the following conclusions can be drawn:

- Curriculum planning for science education is an important function of the educational system. Efforts must be made in relating the curriculum to the national priorities/development programmes
- Curriculum planning for science education must be a common responsibility of all concerned, including those in the non-educational sector
- The formal and the non-formal system must blend and complement each other in the pursuit of interlinked science and technology education
- Approaches to teaching science and technology must be flexible to be responsive to the needs of students and their communities
- The impact of science and technology education on an individual is measured by the subsequent action taken by that individual, either to pursue higher learning or to put the education to work for his livelihood

- The catalytic effect of the knowledge transfer process is a determinant of the desirability of science and technology education
- In interlinked science and technology education, both the transferees of knowledge (students) and transferors of knowledge (teachers) are learners. While the knowledge between them may vary in degree, the end-result directly influences their personal attitude to the knowledge and experience acquired. Similarly, students and teachers develop a positive attitude to "work".
- A continuing mechanism is necessary to sustain the momentum of inter-linked science and technology education. Formal associations or clubs bound by common interests serve as venues for nurturing the enthusiasm of both teachers and students
- Resistance to change or new technology can be offset by awareness campaigns such as those carried out over the mass media
- Sharing of experiences in science and technology education between developing countries must be encouraged in the spirit of international co-operation.

GUIDELINES FOR IDENTIFICATION OF BASIC CONTENT

Technology as part of technical and vocational education (including polytechnic, industrial arts, metal work and woodwork, etc.) already exists in almost all countries. The problem, it seems, lies in introducing it into the general "academic education".

In most developing countries, teachers work within the constraints of a rigid over-crowded school curriculum and its time schedule. Under the circumstances, the Meeting felt that it may not be feasible to include technology as a separate discipline with its own structure and teaching-learning resources in the existing school curriculum. Science is an established discipline and is taught to almost all classes. In its applied form it bears closer relationship to technology education and hence an attempt should be made to re-orientate its teaching to cover general aspects of technology education. Thus the scientific method of problem-solving and decision-making may be taught using design processes, resource utilization and the human purpose. This would help encourage the combination of theory and practice for the benefit of students in their daily life.

The teaching-learning of technology interlinked to science, therefore, should be considered in relation to both the formal and the non-formal systems. The formal system (classroom) imparts directly to the student the basic concepts and principles of science, while the non-formal system (outside the classroom, in the community) enhances the learning process as it influences the application of scientific principles and concepts in the day-to-day life of the student, his family and his community.

This would require a study of existing science curricula with a view to give technological thrusts wherever possible and emphasize the immediate technological environment of students. For example, in teaching the topic on "energy", efficient use of energy resources (e.g. wind, water, solar and fuel) can be discussed with reference to technological innovations for the purpose. Similarly in teaching electricity, students can be encouraged to learn and understand the related technology involved in the design of everyday household appliances; thus developing an appreciation of technology in solving problems

of human purposes.

The environment influences the attitude of students towards the subjects included in the school curriculum. Awareness of links of what is studied in the classroom to what is practised outside the classroom in the community tends to encourage the rate of absorption. Hence, the topics for inter-linked science and technology education should be selected from the socio-economic and cultural environment of the students concerned. A number of traditional technological solutions for day-to-day problems are available in each community - rural or urban. These should be exploited in giving reality as well as relevance to the teaching of science in the country.

The current local agricultural practices, though developed oftentimes by 'hit-and-trial' method, are based on sound scientific principles and socio-economic factors. Their treatment in historical perspective will help develop an understanding of the evolution of these technologies. These can then be linked to the more modern and possibly future technologies through changing socio-economic needs.

Similarly, many scientific principles related to heat, sound, magnetism, chemistry and biology can be studied in relation to a multitude of technologies in the immediate environment of the student. In particular, topics such as food and fermentation processes, water treatment and purification, sanitation, health and hygiene, etc. offer good examples for introducing technology through existing science curricula.

RESOURCES AND CONTSTRAINTS

The Meeting realized that in most developing countries, particularly in rural areas, schools do not possess even nominal laboratory/workshop facilities and equipment. Provision of special equipment and/or facilities needed for introduction of technology as component of general education at the secondary level may prove very difficult if not impossible. Thus to teach technology inter-linked with science, teachers would have to depend and draw heavily on the local environment and community resources related to science and technology. This implies that relevant instructional materials emphasizing the use of available local resources and facilities would have to be developed as a primary necessity. These could be prepared in the form of self-learning modules, units and worksheets stressing skills related to graphical communication, design and assembly processes, problem-solving mechanisms and the evaluation of the finished design or solution. The performance of the final product (e.g. assembled system) or process is as significant as the understanding of the underlying principles. For example, a student may know and understand the mechanism of a simple machine such as a pulley or a lever while ignoring the factor related to the strength of the chord (in pulley) or the rod (lever) necessary for successful performance i.e. lifting the given load in this case.

There is also a shortage of teachers duly qualified and motivated for introducing technology as part of general education. Thus available science teachers would need in-service training and re-orientation in using and developing new instructional materials inter-linking science and technology to achieve the objectives of technology education.

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APPROACHES TO TECHNOLOGY EDUCATION

Technology education permits a wide range of activities and educational purposes, so that a number of different emphases are possible. In designing and structuring a curriculum within these possibilities, selection of a theme and refinement of purpose are necessary. Three perspectives are presented below which have proved helpful in science education and may readily be adapted to technology education. These may be referred to as education IN, ABOUT, and THROUGH technology.

EDUCATION IN TECHNOLOGY

This approach emphasizes the acquisition of some of the knowledge and skills of working technologists. These skills could range from technical routines such as operation of a machine or fault finding in a technical system (electrical or mechanical system of a car) to highly creative activities in design and problem-solving.

Students might explore aspects of design and function by dismantling some simple machines and putting them back together after studying how they work. They might design, build and test a piece of equipment such as a hand-cart, a model suspension bridge, or a burglar alarm. They might invent a procedure, perhaps to move a large desk through a small door. At a more advanced level, they might design an efficient bottle-washing plant, or, for a remote community, a complete energy system appropriate to the social, economic and environmental requirements of that community.

The knowledge that is required needs to be defined by the problems and situations being addressed. It is likely to include the properties and behaviour of different materials, understanding of relevant scientific principles, and insight into social, economic and environmental factors. This encompasses a large number and range of concepts and hence involves a greater number of facts. The important characteristic of this approach is that the knowledge is introduced and learned in the context of solving a particular problem. It is not acquired "for its own sake", but for its application.

Skills requiring direct attention may include technical skills in handling some of the tools currently used in the production and maintenance of equipment e.g. lathes, soldering irons, meters, sewing-machines, word processors and graphic communication (line drawings and circuit diagrams). At a second level would be skills related to situational analysis, problem resolution, and decision making including modelling of the situation, clarification of the situation, clarification of the problem and related issues, proposal of solutions and assessment of the appropriateness of solutions as well as the implementation of the chosen one.

Emphasis on education IN technology would require learning experiences strongly based in activity: students would require opportunities to make, build and experiment to develop concepts through first-hand experience, to practise their skills and apply their learning.

Within this framework one of the pressing problems is to match the experience and the technologies presented in schools to the kinds of experience and technologies which await young people when they leave school. This problem is inevitable when education in technology focuses on specific skills, techniques and machines which will be immediately and directly valuable in the workforce.

EDUCATION ABOUT TECHNOLOGY

"Education about Technology" has always been a concomitant, to some extent, of education in technology. Moreover, in other areas of the curriculum, such as in natural and social sciences, consideration of the impact of technology has received a fresh impetus in recent years.

Thus, this approach is seen as one which examines technology in our culture. Here the emphasis is on studying the record of technological developments with attendant achievements and problems in their social context. The strategy serves the educational purposes of assisting students to understand and cope with technological and social change and to participate in technological decision-making at the governmental level. It also admits technology as part of our cultural achievement and contributes to the goal of cultural enlightenment.

Accordingly, students might, through case-studies of inventors and inventions, study the ways in which ideas are generated. They might examine the context of particular inventions noting the extent of problems solved, and other discoveries or pressures which made the development appropriate at that time.

They might also pursue the cultural and social impact of particular inventions and technological developments. They might even look into techniques of technological forecasting and technology assessment, including the indirect and unanticipated effects of technological developments. They might examine alternative technological futures as well as the question of who controls the direction of technological developments.

Teaching methods could include reading assignments, discussion and debate as well as activities involved in technological design and production. Depending upon the topic concerned, an understanding of technical knowledge on the part of the teacher may or may not be required. For example, when considering the social impact of the development of railways, it may be of little value to understand the workings of the steam-engine or the laying of railway-tracks. However, for topics such as the development of plastics, an understanding of the technical aspects would be essential. While teachers will not need to be experts in a large number of particular technologies, some background in technology and knowledge of socio-cultural and economic factors which define the context of a technological development would be imperative.

EDUCATION THROUGH TECHNOLOGY

Technology education may be regarded as a means of achieving the goals of general education rather than as an end in itself. Although goals of general education are bound to their social context, they have always involved improved thinking abilities, greater power over one's own life, progress towards self-realization, and development of citizenship and social responsibility. These goals can be approached by education through technology. This provides familiarity with and understanding of technology which increase self-confidence and personal power in a technological environment. It develops skills in logical reasoning, analysis, evaluation and decision-making, with concomitant preferences to seek information and clarify values before making decisions. It provides opportunities to develop manual skills and creative abilities. It promotes general understanding which may assist students, as adults, to participate in and contribute to their society.

While these three kinds of technology education are conceptually separate, in practice they must be mixed. The question is one of emphasis. For example, it would be impossible to conduct "education in technology"

without touching either education through or about technology. At the same time, concerns for education through technology in a curriculum emphasizing education in technology encourage a teacher to capitalize on activities in different ways rather than on routine technical skills. Similarly, education through technology cannot occur except by students "doing" technology. Thus emphasis on education through technology will discount as a school function the selection and preparation of future engineers in favour of more general functions of education for living in our technological world.

ORGANIZATION OF THE CURRICULUM

Technology education, with its emphasis on the development of skills and their application to human purposes, is clearly interdisciplinary in terms of the traditional curriculum. As such, it may be offered as a separate subject or it may be built into existing subjects such as science, home economics, social studies etc. as a formal component. It could also serve as a unifying theme for a number of subjects through a topic approach or might assume a central position for a section of curriculum involving project activities.

The way a particular school chooses to present technology education must depend on details of content and aims, as well as the nature and extent of resources and constraints inherent to its local or national system of education. The important first step is acceptance of the value of technology education to our children and society in general and its relevance to their immediate and future needs in particular.

TEACHING METHODS

The variety of goals and content within technology education require a range of teaching methods involving individual and group practical activities, library research, discussion and exposition by the teacher. Notwithstanding this variety, the process of technological development, the goals of technology education, and recent developments in pedagogy and learning theory combine to make a strong case for an activity-based, enquiry-approach to technology teaching. Students, from time to time, need to be actively involved in the process of technological development, including the design process, realization and trial of a technological solution, analysis of the problem to be solved, and evaluation of the effectiveness and the side-effects of potential solutions.

TEACHER PREPARATION AND IN-SERVICE COURSES

If students are to display a high degree of independence, initiative and responsibility for their own work - if the project is to place students in the role of active problem-solvers - the curriculum materials cannot be of a sort which attempts to restrict teachers into activities where they are expected to faithfully execute tightly defined activity. To put it most basically, teachers need to be encouraged to become pedagogical problem-solvers in their own right if they are to encourage similar habits among their students.

In the pilot stage of the project, it has been thought that teachers are best prepared to use a problem-solving emphasis if they are themselves provided with sets of case-studies prepared by other teachers. Such an approach would allow teachers to see the exemplary nature of the materials, to envisage new roles for themselves and their students, to permit elaboration of the contextual features of the problem, as well as to plan activities in which students can participate.

In developing and using exemplary materials, teachers need support and encouragement to work together in their own school. This will need strong support from the local school administration and authority to provide opportunities for teachers to visit other schools attempting similar projects, and to participate in in-service training. Such in-service training activities could be held among several interested schools, especially when talented teachers are thinly spread. The support of regionally-based supervisors, inspectors and curriculum specialists will also be invaluable in strengthening such in-service training programmes.

ASSESSMENT AND EVALUATION PROCEDURES

When the objectives are prescribed uniformly for all students, or where learning materials are highly structured, assessment of student achievement is determined accordingly. In such circumstances it may be enough to ascertain whether students have followed instructions accurately, whether they worked competently with the materials to complete their assigned task; and/or whether they could explain what they did.

Whereas these attributes remain important to this project, they need to be complemented by the inclusion of alternative models of evaluation and assessment which are more closely attuned to the broad educational objectives of this project. Some quantitative evaluation of the products of a problem-solving exercise may be appropriate. But it may be even more appropriate to look at qualitative aspects of the "solution" as well. It is also desired to consider the knowledge, skills and attitudes gained by the student as a result of working through a problem. In particular, it is important to assess how well students plan and organize their own attempts at a solution; to examine whether these attempts represent a worthwhile use of time for students, parents, or the school. Of equal significance will be students' ability to recognize and deal with unexpected outcomes or problems along the way.

Specific evaluation procedures, however, should involve students in a collaborative approach to appraising and reporting their own work. The following possibilities may be suggested:

1. Students writing a report to explain what they have done.
2. Students to prepare a guide or an information book to assist other students who are likely to undertake a similar project; indicating what should be avoided and what should be looked for, etc.
3. Teachers and others involved in supporting the project could be asked to provide their evaluation as to how well the problem was tackled.
4. Teachers, students and parents could be invited to provide their own evaluation of the project - how successful it was, what it achieved for the students involved, etc.
5. Students could also be invited to respond to some open-ended questions, such as what they regarded as good things, valuable things, things which they liked about this project..... bad things, things of no value, things which they disliked about the project.....
6. Last, but not least, students might be asked to give a rating to their own statements, placing them in order of preference.

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